"Every Boy & Girl a Scientist"

Instruments for Children in Interwar Britain

By Melanie Keene*

ABSTRACT

Historians of science have identified toys as part of their subject's material culture, but there has been little exploration of the production and use of educational or playful objects. Moreover, academic writing on science for children has focused on the eighteenth and nineteenth centuries. This essay argues that our understanding of historical science education can be enhanced by exploring twentieth-century instruments. It uses the example of Construments sets, with which children could build a wide variety of optical instruments from a series of standardized parts. Invented by C. W. Hansel, a school science master, Construments were founded in and responded to contemporary educational practices and debates over "general science," as well as addressing characteristic interwar concerns about adaptability and economy and older ideals of rational entertainment. By exploring the company's instruments, promotional literature, and magazine, and by drawing on the memories of contemporary users, I reconstruct the contexts in which Construments were used, emphasizing the creation of heterogeneous communities vital for the transmission of skills and knowledge.

ON CHRISTMAS DAY 1935, twelve-year-old Edward Blackwell unwrapped his brand-new Construments optical instrument construction kit. Tearing off the paper, he was confronted with a colorful box to open: the kit's red, white, and blue packaging exhorted him to create optical marvels and amazing photos and promised a hobby of "ten thousand thrills." Edward, like "every boy & girl" fortunate enough to have a Construments set, could become "a scientist." He lifted the lid to discover an array of components, neatly stored in a series of drawers. As he later recalled, the kit "consisted of lenses, prisms, pinhole discs, etc., plus stands and holders, enabling one to make do-it-yourself micro-

* Department of History and Philosophy of Science, University of Cambridge, Free School Lane, Cambridge CB2 3RH, United Kingdom.

I would like to thank *Isis* Editor Bernard Lightman and three anonymous referees for their very helpful comments and suggestions for revising this article. Also, many thanks to Jim Secord, Simon Schaffer, Liba Taub, Ruth Horry, and the Whipple Museum for the History of Science, Cambridge. I am grateful to the British Library for permission to reproduce images from material held in their collections. My work has been funded by the Arts and Humanities Research Council of Great Britain.

Isis, 2007, 98:266–289

0021-1753/2007/9802-0002$10.00

scopes, telescopes and the like."[1] Guided by the set's instruction manual, he would go on to construct instruments that fed his enthusiasm for the sciences, training his powers of observation and mental reasoning in a Constructments Club formed with like-minded friends. This essay uses Constructments kits such as Edward's to investigate the experience of learning about the sciences in interwar Britain. I will argue that this involved not just an individual reading on his or her own but, rather, the experience of constructing instruments and, with them, manual skills, mental habits, and scientific communities.

Despite an increasing emphasis in the history of science on the practice and equipment of the scientific enterprise and on the activities of nonspecialist groups, there have been few academic studies of toy sets. It has been twenty years since Gerard Turner surveyed playful objects for his presidential address to the British Society for the History of Science, yet few historians of science have heeded his implicit call to look more closely at such items.[2] Research into recreational science more generally has focused on individual inquiry through eighteenth- and nineteenth-century texts, and this has been reflected in work on children's experiences.[3] Though many of these studies have been exemplary, I hope in this essay to extend the scope of their inquiry to include both the twentieth century and interactions with material objects.

Historians of education have looked in more detail at this later period, with works including David Layton's *Science for the People* (1973), Edgar Jenkins's *From Armstrong to Nuffield* (1979), Gary McCullough, Jenkins, and Layton's *Technical Revolution?* (1984), and Jenkins and B. J. Swinnerton's *Junior School Science Education in England and Wales since 1900* (1998) providing surveys of British science teaching; these texts concentrate on the school environment, however, and three are by now rather dated. More recently, attempts to introduce general science to American children at the beginning of the twentieth century have been investigated in *Isis* by John Rudolph.[4] My study provides a comple-

[1] Edward Blackwell, *The Unfolding Years: Memoirs of a Bourgeois Childhood* (London: Athena, 2003), p. 135. Although it is unclear whether Blackwell received his set for Christmas, given the importance of the festive market to Constructments' advertising strategy it does not seem too great a conjecture to make. Blackwell's autobiography details his Midlands youth during the Depression and ends with his acceptance to Oxford University to read Natural Science. Apparently he wished to become a biochemist, but in the end he spent his later life as an accountant and businessman.

[2] For work that explicitly discusses these objects see Gerard Turner's survey "Presidential Address: Scientific Toys," *British Journal for the History of Science,* 1987, *20*:377–398; Brian Gee, "Amusement Chests and Portable Laboratories: Practical Alternatives to the Regular Laboratory," in *The Development of the Laboratory: Essays on the Place of Experiment in Industrial Civilization,* ed. Frank A. J. L. James (Basingstoke: Macmillan, 1989), pp. 37–59 (an investigation of nineteenth-century chemistry sets); Carroll W. Pursell, Jr., "Toys, Technology, and Sex Roles in America, 1920–1940," in *Dynamos and Virgins Revisited: Women and Technological Change in History: An Anthology,* ed. Martha Moore Trescott (Metuchen, N.J./London: Scarecrow, 1979), pp. 252–267; and Deborah J. Warner, "Commodities for the Classroom: Apparatus for Science and Education in Antebellum America," *Annals of Science,* 1988, *45*:387–397 (a consideration of school equipment).

[3] Work on this topic includes Aileen Fyfe, "Young Readers and the Sciences," in *Books and the Sciences in History,* ed. Marina Frasca-Spada and Nicholas Jardine (Cambridge: Cambridge Univ. Press, 2000), pp. 276–290; the series of nineteenth-century reprints in Fyfe, ed., *Science for Children* (Bristol: Thoemmes, 2003); Greg Myers, "Science for Women and Children: The Dialogue of Popular Science in the Nineteenth Century," in *Nature Transfigured: Science and Literature, 1700–1900,* ed. John Christie and Sally Shuttleworth (Manchester: Manchester Univ. Press, 1989), pp. 171–200; James A. Secord, "Newton in the Nursery: Tom Telescope and the Philosophy of Tops and Balls, 1761–1838," *History of Science,* 1985, *23*:127–151; and Jonathan R. Topham, "Periodicals and the Making of Reading Audiences for Science in Early Nineteenth-Century Britain: The *Youth's Magazine,* 1828–37," in *Culture and Science in the Nineteenth-Century Media,* ed. Louise Henson *et al.* (Aldershot: Ashgate, 2004), pp. 57–70.

[4] David Layton, *Science for the People: The Origins of the School Science Curriculum in England* (London: Allen & Unwin, 1973); Edgar William Jenkins, *From Armstrong to Nuffield: Studies in Twentieth-Century Science Education in England and Wales* (London: Murray, 1979); Gary McCullough, Jenkins, and Layton, *Technical*

mentary examination of instruments and education: rather than analyzing in detail the developments in school curricula, however, I demonstrate how an object with its origins in such debates was invented, marketed, and used in the home.

My focus is therefore instrumental. As the manifold and shifting definitions of "scientific instrument" have been widely debated, the role of toys has been appreciated as part of science's material culture. Works such as Thomas L. Hankins and Robert J. Silverman's *Instruments and the Imagination* (1995) have provided analyses of the historical meanings and uses of specific instruments but have not addressed the question of their educational roles in detail, particularly with respect to toys. Karin Calvert's *Children in the House: The Material Culture of Early Childhood, 1600–1900* (1992), investigated the objects of childhood, with some emphasis on late eighteenth- and early nineteenth-century scientific education, though she did not trace the successors to these developments.[5]

While sociologists have emphasized the importance of play in the development and education of children's bodies and minds, the contribution to the scientific enterprise of items specifically designed to be played with has yet to be situated in a precise historical context. Johan Huizinga's classic work *Homo Ludens* (first translated into English in 1949) traced the ubiquity of play in human cultures, and Iona and Peter Opie's *Children's Games with Things* (1997) listed traditional pastimes such as playing marbles or skipping and examined how material objects are involved in these pursuits. Marina Warner's curated exhibition at Compton Verney in 2005 attempted to combine childhood objects with an exploration of "Ways of Playing" and linked play, art, and creativity. Through my investigation of children's scientific instruments I hope similarly to connect these analyses to existing studies of how the sciences were rendered "instructive and amusing," as skills of deduction and reasoning were entrained through demonstration and play.[6]

I will introduce Construments Ltd. by investigating how the company promoted its products and tailored its kits to suit the contemporary market for affordable scientific and constructional toys and as part of a tradition of optical amusements. I will then examine the ongoing educational debates over heuristics and so-called general science, in response to which the outfits were created. The actual construction of instruments was perceived to provide children with an introduction to basic and generalized scientific skills and also licensed a degree of creativity. Since mental processes were entrained by the physical

Revolution? The Politics of School Science and Technology in England and Wales since the Second World War (London: Falmer, 1984); Jenkins and B. J. Swinnerton, *Junior School Science Education in England and Wales since 1900: From Steps to Stages* (London: Woburn, 1998) (Jenkins has also edited a collection entitled *School Science and Technology: Some Issues and Perspectives* [Leeds: Centre for Studies in Science and Mathematics Education, 1993]); and John Rudolph, "Turning Science to Account: Chicago and the General Science Movement in Secondary Education, 1905–1920," *Isis,* 2005, *96*:353–389.

[5] Gerard Turner, "Presidential Address: Scientific Toys" (cit. n. 2); Albert Van Helden and Thomas L. Hankins, "Introduction: Instruments in the History of Science," *Osiris,* 1994, *9*:1–6; Deborah J. Warner, "What Is a Scientific Instrument, When Did It Become One, and Why?" *Brit. J. Hist. Sci.,* 1990, *23*:83–93; Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton, N.J.: Princeton Univ. Press, 1995); and Karin Calvert, *Children in the House: The Material Culture of Early Childhood, 1600–1900* (Boston: Northeastern Univ. Press, 1992). For sociological treatments of scientific technologies see David Gooding, Trevor Pinch, and Simon Schaffer, eds., *The Uses of Experiment: Studies in the Natural Sciences* (Cambridge: Cambridge Univ. Press, 1989).

[6] Johan Huizinga, *Homo Ludens: A Study of the Play Element in Culture* (1949; London: Temple Smith, 1970); Iona Opie and Peter Opie, *Children's Games with Things* (Oxford: Oxford Univ. Press, 1997); and Marina Warner, curator, *Only Make-Believe: Ways of Playing* (Compton Verney, 2005). Jeffrey H. Goldstein, ed., *Toys, Play, and Child Development* (Cambridge: Cambridge Univ. Press, 1994), gives rather general and contemporary, but still useful, analyses. For more on the use of the "instructive and amusing" category see Fyfe, "Young Readers" (cit. n. 3), p. 276.

manipulation of objects, proponents urged that such an education was suitable for all children, not just those who were destined to progress to a scientific career. An analysis of how Constructments were linked to the popular contemporary subject of detectives and detection provides an illustration of how this message was reinforced by the company. Next I explore the use of a Constructments outfit, demonstrating how engaging and playing with the set was perceived to mimic the course of a scientific education, beginning with the naming of components and the elementary construction of models and progressing to unconstrained experimentation. Problems encountered when using the set could be solved by reference to the wider Constructments community, and it is to these groups that I finally turn, demonstrating how an emphasis on collaboration and societies enriches our understanding of what it means to learn about the sciences. In all these ways, a popular optical toy provides new insights into the contribution of objects to scientific education.

SELLING SCIENCE

The first Constructments outfits appeared on the market in late November 1932, described by the *London Times* as "a new scientific constructional set which makes a variety of working instruments and should provide many hours of concentrated industry for the holidays." The kits had been invented by Carl (August) Weston Hansel (1898?–1967), school science master at Bedford School, who became one of Constructments Ltd.'s directors; the others listed on the letterhead were Ellison Hawks, Sir Christopher Magnay, Capt. P. Musker, L. Smith, M. E. Stuttard, and Sir George Lacon. The company marketed three different products—the "20" (see Figure 1), "Plus," and "100" outfits—from a base at 18 Gray's Inn Road, London, W.C. 1. The sets' interchangeable component parts were cata-

Figure 1. *The inside of a Constructments "20" set. (From author's collection.)*

logued and labeled in the accompanying instruction manual, which detailed how Construments models could be put together. Clear diagrams, standardized parts, and step-by-step instructions were included to aid boys and girls in building a range of scientific optical instruments, including "Magnifiers, Kaleidoscopes, Low Power Microscopes, Pocket Cameras, Photocopiers, [and] Periscopes."[7]

The scientific instruments that could be made with a Construments outfit therefore built on a much older tradition of toys, optical tricks, and natural magic, such as nineteenth-century magic lantern shows. For example, David Brewster's 1832 *Letters on Natural Magic* was quoted admiringly in Construments' accompanying monthly journal, the *Construmag,* which was published from 1933 to mid-1934. Similarly, the professed slogan of the London Stereoscopic Company, founded in 1854, had been "a stereoscope for every home"; Construments echoed this ambition in aiming to make "every boy & girl a scientist." Thus Construments exploited conventional means of rendering the sciences entertaining in order to capture the attention of their juvenile audience. As Jennifer Tucker has shown with another popularized technology, photography, they struck "an elusive balance between 'science' and 'show.'" Contemporary books written for this audience similarly drew on a genre of "wondrous" events and occurrences; Construments director Ellison Hawks was the author of many such works, including *The Book of Electrical Wonders* (1929) and *The Book of Natural Wonders* (1932).[8]

Demonstration, display, and advertising were central parts of the Construments marketing strategy from the outset. The company circulated reports of exhibitions at which its wares had been presented, including the Conversazione of the Regent Street Polytechnic, London, in late 1932, and the Hobbies and Models Exhibition of January 1933 at City Hall, Manchester, claiming that these events were a great success: "Everyone who has seen Construments, young or old, is absolutely wild to possess an outfit of their very own. The earlier models of Construments have been exhibited and demonstrated before learned societies, scientific bodies and educational authorities, etc., and everywhere the idea has been hailed as the greatest contribution to 'science made easy' ever introduced."[9]

Just like the optical instrument sets themselves, these public events brought together "science" and "show." The Manchester exhibition included illuminated working models, as well as aquaria containing "Water Lice, Water Beetles, Baby Catfish, Fresh Water Snails and Whelks," which "helped to make the stand a centre of interest."[10] Providing the appropriate packaging was hence crucial for the company's development.

The company stressed the value of the apparatus one could construct by naming the outfits after the supposed cost of purchasing all the individual instruments: the "20" set made "£20 worth," the "100" set "£100 worth" of instruments. Construments' promotional rhetoric claimed that "it would cost over £100 to purchase separately instruments equal to

[7] *London Times,* 21 Nov. 1932, p. 9 (see *Other Systems Newsletters,* [1999?], *19,* p. 554, for corroboration of this date). The directors' names are taken from Construments Ltd. headed notepaper: Tony Knowles, personal communication, 21 Jan. 2005. The description of the instruments is from the lid of a Construments "10" outfit (see Figure 2).

[8] See Turner, "Presidential Address: Scientific Toys" (cit. n. 2), pp. 389–393 (on the older tradition); Hankins and Silverman, *Instruments and the Imagination* (cit. n. 5), p. 149 (stereoscope slogan); Jennifer Tucker, "Photography as Witness, Detective, and Impostor: Visual Representation in Victorian Science," in *Victorian Science in Context,* ed. Bernard Lightman (Chicago/London: Univ. Chicago Press, 1997), pp. 378–408, on p. 394; Ellison Hawks, *The Book of Electrical Wonders* (London: Harrap, 1929); and Hawks, *The Book of Natural Wonders* (London: Harrap, 1932).

[9] *Construmag,* Feb. 1933, p. 28; and Construments promotional leaflet, pp. 5–6 (quotation).

[10] *Construmag,* Feb. 1933, p. 28.

those that you can build with the Constructments Outfit costing *shillings!*" It also advertised this "new invention" as a "means of realising the hitherto Utopian desire for *cheap* instruments and apparatus." In the worldwide Depression following the 1929 Wall Street crash, scientific education had become particularly linked to calls for the practice of "economy." This was debated overtly in the pages of the *School Science Review,* yet more subtle connections were also made: the *Times* concluded a report on a Christmas exhibition, in which it claimed that "'Constructments' sets are favourites with boys and girls who like a scientific educational toy," by noting as well that "the bulk of the money spent on these gifts has given employment to thousands of British workers."[11]

As part of this emphasis on economy, then, the company highlighted the adaptability, multipurpose nature, and relatively cheap cost of its outfits: "Constructments consist of simple interchangeable parts, each of which can be used for many purposes. It is the most economical and simply constructed apparatus obtainable, in addition to being the cheapest." Hansel, Constructments' inventor, wrote: "in the interests of economy, apparatus must be inexpensive but adaptable, and it should be capable of easy and universal adjustment in so far as this is required." Other contemporary products, too, addressed a wider commercial culture concerned with economy, standardization, and adaptability: a 1933 event at which the sets were displayed also exhibited, alongside "fine specimens of handicraft," what might be called the Constructments of the furnishings industry: "cheaper but well designed and constructed, machine-prepared and mass-produced furniture of the type widely required for small houses and flats." Crucially, novel products at the exhibition included "pieces which are adaptable for various uses."[12]

Despite the company's emphasis on the economically low price of the instruments, Constructments were nevertheless perceived by consumers as relatively costly purchases. Frank Hanby remembered the expense of the outfits: "At Christmas 1935, with the assistance of a good salesman at Hamleys, my mother bought me a DE LUXE set, with the proviso that it would be unwise to tell Dad—I now realise that 39/6 was a fairly large sum of money in those far off days."[13]

Sold at Hamleys—the country's flagship toy store on Regent Street, which had been the world's biggest such shop only a few years before—Constructments were for many a luxury item. Perhaps seeking to turn this potential problem into a virtue, Constructments upheld the status of their products by marketing them as gifts, with slogans such as "Never before a gift like this" and "The greatest educative present for boys and girls" printed on the boxes. The smaller "20" sets even came gift-wrapped in promotional literature, with images of children using Constructments outfits on the box (see Figure 1). The *Construmag* continued this emphasis, claiming after the Manchester exhibition that "many were the

[11] Constructments promotional leaflet, p. 2; and *London Times,* 22 Dec. 1933, p. 7. On the matter of "economy" in science see Jenkins, *From Armstrong to Nuffield* (cit. n. 4), p. 75; for the effects of the Depression on the British toy industry see Kenneth D. Brown, *The British Toy Business: A History since 1700* (London: Hambledon, 1996), pp. 125–128.

[12] C. W. Hansel, "Preface," in J. Harold Getliffe, *Constructments Manual of Experimental Science* (Bedford: Rush & Warwick, 1934), p. iv; Hansel, "Suggestions Relating to Reform in the Teaching of Geometrical Optics," *Proceedings of the Physics Society,* 1928, *41*:270–273, on p. 271; and *London Times,* 22 Dec. 1933, p. 7. For a recent twist on these ideas see F. Quercioli, B. Tiribilli, A. Mannoni, and S. Acciai, "Play Optics with LEGO™," *Proceedings of the Fifth International Topical Meeting on Education and Training in Optics* (1997), pp. 233–242, online at http://www.spie.org/communityServices/StudentsAndEducators/etop/1997/233_1.pdf. Like Hansel, these authors claim that "in a laboratory setup for educational purposes (or even for research) low cost, reduced weight and compact size are all desirable characteristics. Versatility, quickness and ease of assembly are also extremely valuable" (p. 233).

[13] Frank Hanby, quoted in *Other Systems Newsletter,* [1992?], *5,* p. 79.

Figure 2. *A Constructments "10" set. Whipple Museum accession number Wh.4565. (Image courtesy of the Whipple Museum of the History of Science, University of Cambridge.)*

promises extracted from parents [by their children] to 'get me a set—for my birthday.' . . . After all, could there be a more acceptable gift to an enthusiastic young student?"[14] In these ways, Constructments were promoted as an exceptional educational purchase that nevertheless provided value for money.

In 1933 a cheaper, 10 shilling "10" set was introduced, advertised in the *Times* as "a popular size . . . to meet the pockets of those who prefer to start their young people with a smaller set" (see Figure 2). As well as being sold at the elite Hamleys establishment, these outfits were widely available across England and Wales in the early 1930s—including at more than two hundred Halford depots, a retailer that also provided components for model radio hobbyists. Nevertheless, the company could not economize too much without attracting adverse comment: one reviewer's "only criticism" of the Constructments "scheme" was "that the interchangeable parts would probably find more favour if they were a little heavier in make, and correspondingly more robust in appearance."[15]

Aware of the possibility that their outfits, and attendant educational ambitions, could be

[14] *Construmag,* Feb. 1933, p. 28. On Hamleys see http://www.hamleys.com/web/about/ (accessed 6 June 2005).
[15] *London Times,* 22 Dec. 1933, p. 7; *Construmag,* Feb. 1933, p. ii; and Allan Ferguson, "Lecture and Instructional Apparatus," *Journal of Scientific Instruments,* 1932, *9*:55–58, on pp. 57–58.

dismissed as too fragile or toylike, Constructments promotional leaflets lauded the products as enabling "Home Science, Entertainment & Experiment with Genuine Scientific Apparatus." They explained that the sets contained "simple parts from which an immense variety of actual working instruments can be constructed." Moreover, they made reference to the company responsible for their production, claiming that the "quality of Constructments is sufficiently guaranteed by the fact that all the standardised and interchangeable metal parts have been manufactured by THE BRITISH THOMSON-HOUSTON CO. LTD." British Thomson-Houston (BTH) was founded in 1896; by the 1930s its manufacturing base was located in Rugby, not far from where Hansel taught at Bedford School. In 1928 BTH had merged with Metropolitan-Vickers Company, which provided instrumentation for many key experiments conducted at Cambridge University's Cavendish Laboratory in the early 1930s.[16] Hence, Constructments belonged on a continuum that stretched all the way from large-scale academic and industrial science to science as it might be practiced in every home or school, a standing reiterated by the company's insistence that its outfits made "REAL full-size Working Instruments—not mere 'toys' or models." Indeed, Hansel himself had stressed the importance of close "and expert collaboration between teachers and industrialists."[17] Constructments outfits were therefore marketed as appealing, affordable, and actual instrument products, selling the idea of a scientific education to contemporary consumers.

CONSTRUCTING AN EDUCATION

More than just a desirable consumer good, however, Constructments sets were invented as a response to the educational debates of the 1920s and 1930s, intended to combat perceived shortcomings in contemporary educational practice. As Hansel wrote in a 1928 article on the proper teaching of optical science:

> Perhaps the most important defect of present-day teaching is that it fails to supply a sufficient practical acquaintance with optical instruments and their performance. . . . The construction of optical apparatus and instruments . . . is most seriously neglected. Apparatus and instruments should be capable of assembly in more than one way, and the discovery of the best method of construction and arrangement, and a criticism of inferior designs, is an essential and valuable course of practical training.[18]

Hansel had graduated with first-class honors in physics and maths from London University, was then Demonstrator of Physics at Imperial College of Science and Technology, and, at

[16] Constructments promotional leaflet, pp. 1, 2; see also *Other Systems Newsletter,* [1992?], *19,* p. 554. On BTH see http://www.marconi.com/Home/about_us/Our%20History/GEC%20Heritage/British%20Thomson-Houston%20History (accessed 6 June 2005). On the company's similar role in Cavendish physics see T. E. Allibone, "Metropolitan-Vickers Electrical Company and the Cavendish Laboratory," in *Cambridge Physics in the Thirties,* ed. John Hendry (Bristol: Hilger, 1984), pp. 150–173; and Jeff Hughes, "Plasticine and Valves: Industry, Instrumentation, and the Emergence of Nuclear Physics," in *The Invisible Industrialist: Manufactures and the Production of Knowledge,* ed. J.-P. Gaudillière and I. Löwy (Basingstoke: Macmillan, 1998), pp. 58–101, esp. pp. 69–70.

[17] Constructments promotional leaflet, p. 5; and Hansel, "Suggestions Relating to Reform in the Teaching of Geometrical Optics" (cit. n. 12), p. 271. See also John Hendry, introduction to "Part 3: Underlying Themes," in *Cambridge Physics in the Thirties,* ed. Hendry, pp. 103–124, esp. p. 120; Hughes, "Plasticine and Valves," p. 60; and Guy Hartcup and T. E. Allibone, *Cockcroft and the Atom* (Bristol: Hilger, 1984), pp. 28–58.

[18] Hansel, "Suggestions Relating to Reform in the Teaching of Geometrical Optics," p. 271. See David Follett, *The Rise of the Science Museum under Henry Lyons* (London: Science Museum, 1978), p. 113, for the Science Museum's 1929 acknowledgment that "boys and girls should make models themselves" but that the "Science Museum cannot do that work."

the time of writing about education and inventing Construments, was employed as senior science master at Bedford School. In 1932 Bedford School began construction of a new science building; it was completed by October 1933, when the Prince of Wales visited. Despite at first mistaking the science block for the prep school, His Royal Highness apparently "showed considerable interest in the equipment." We can speculate that Hansel initiated Bedford's educational innovations; unfortunately, the only reference to him in the school's archives notes a donation of £1/1s he made in February 1930.[19]

Construments sets had been presented as educational objects at dedicated pedagogical events in the years before they entered commercial manufacture, receiving mostly positive assessments from contemporary reviewers. For example, the *Journal of Scientific Instruments* reported that "'Construments' represent a thoroughly interesting attempt to provide at a very reasonable expense a series of interchangeable components by means of which the ordinary optical bench experiments may be easily and accurately carried out. Certainly the writer had never appreciated the possibilities of two-volt and six-volt flashlight lamps as sources of illumination for low-power microscopes, mirrors and scales and the like until he saw [Construments'] simple and effective arrangements."[20]

Responding to the company's self-promotion, some reviewers thus acclaimed the sets as a novel response to problems of repeating small-scale experiments; another writer in the same journal, however, saw in Construments sets a successor to an interchangeable apparatus employed at the University of Cambridge in the nineteenth century. Described in Robert Willis's 1851 *A System of Apparatus for the Use of Lecturers and Experimenters in Mechanical Philosophy,* this "system of mechanical apparatus [consisted] of the separate parts of which machines are made, so adapted to each other, that they might admit of being put together at pleasure in the form of any machine that might be required." Like Construments, the nineteenth-century system was dubbed a "Protean mechanism," designed to circumvent the "bulk and expense of a collection of separate models, which must always oppose great obstacles to the teaching of this subject." Apparently these instruments never reached a wide audience owing to their large size. Construments' "neat contrivances," on the other hand, were "much more suitable."[21]

In the second half of the nineteenth century—between the time of Willis's description of his set and the display of Construments to the *Journal of Scientific Instruments* reviewers—there had been an enormous growth in the number of assembly kits produced, a development Christoph Meinel describes as testifying to the "spread of construction thinking through Europe." Of these systems, the small and versatile Meccano sets, created by Frank Hornby at the beginning of the twentieth century, achieved the greatest success, and visitors to the Manchester exhibition would have caught the echo of Meccano's

[19] On Hansel see Hansel, "Preface," in Getliffe, *Construments Manual of Experimental Science* (cit. n. 12), p. iv. For his writings on teaching physics see C. W. Hansel and P. Woodland, *An Introductory Electricity and Magnetism* (London: Heinemann, 1930); and Hansel, *Examples in Numerical Physics,* Vols. 1–3 (Cambridge: Cambridge Univ. Press, 1937). Though I have been unable to obtain further information about his life, Hansel appears to have continued to publish articles in this field. The prince's visit to Bedford School is described in Michael De-la-Noy, *Bedford School: A History, 1552–2002* (Bedford: Bedford School, 1999), pp. 114–115; Hansel's donation was reported by T. Taylor, Bedford School assistant archivist, personal communication, 12 Nov. 2003.

[20] Ferguson, "Lecture and Instructional Apparatus" (cit. n. 15), pp. 57–58.

[21] C. R. Darling, "Special Educational Apparatus," *J. Sci. Inst.,* 1929, *5*:79–80, on p. 79; and Robert Willis, *A System of Apparatus for the Use of Lecturers and Experimenters in Mechanical Philosophy* (London: John Weale, 1851), p. 1. However, the instruments Willis describes may have been intended only for use as demonstration devices during lectures and not marketed as a consumer product.

original name—"Mechanics Made Easy"—in Construments' "science made easy." One reviewer at an earlier educational exhibition drew the comparison: both systems consisted of "standardized parts which can be assembled in various ways." The number of Meccano sets manufactured increased dramatically in the interwar years as part of wider social moves toward indoor play and the growing influence of cut-price department stores, of which Woolworths is the most famous British example. At this time Meccano itself saw the potential of addressing, or creating, a scientific audience with their products: the company's chemical "Kemex" sets were introduced in 1933, advertised alongside its electrical outfits in a series of articles in the 1934 issues of the *Meccano Magazine.* Actual, as well as ideological, links connected Construments and Meccano: from 1921 to 1935 Ellison Hawks was the editor of the *Meccano Magazine* and in charge of advertising for the Meccano company.[22]

Construments sets conformed to Hansel's own educational vision, responding to and extending his belief that pupils needed to build their own instruments as part of practical scientific investigation. One early reviewer criticized the kits, however, arguing that students could spend all of their time constructing instruments rather than doing experiments with them: "the drawback to the use of contrivances of this kind is that the time spent in the erection cannot always be spared by the teacher, and there is a danger that the student may give more attention to the constructional part than to the subjects for which the finished apparatus is designed."[23] Construments could be seen as providing a good mechanical, but not necessarily a good scientific, education.

However, in highlighting the importance of a primarily practical acquaintance with the perhaps more mechanical methods and materials of science, Hansel drew on long-standing debates over the ways in which children should learn about the natural world; in particular, his ideas can be linked to Henry Edward Armstrong's heuristic educational theories of the preceding thirty-five years. Armstrong's methods involved "placing students as far as possible in the attitude of the discoverer"; he argued that educational practices should "involve their *finding out,* instead of being merely told about things." Just as Armstrong endeavored to recreate the "real" activities of scientists through his pedagogical methods, Hansel and Construments provided children with emphatically real scientific instruments and urged them to employ these tools to investigate, elucidate, and discover the natural world as scientists themselves. The Hadow Committee's report to the Board of Education in 1931 asserted that elementary education should consist of "activity and experience, rather than of knowledge to be acquired and facts to be stored."[24]

[22] Christoph Meinel, "Molecules and Croquet Balls," in *Models: The Third Dimension of Science,* ed. Soraya de Chadarevian and Nick Hopwood (Stanford, Calif.: Stanford Univ. Press, 2004), pp. 242–275, on p. 269; Bert Love and Jim Gamble, *The Meccano System and the Special Purpose Meccano Sets, 1901–1979* (London: New Cavendish Books, 1986), pp. 16, 126 ("Kemex" sets), 82, 162 (Hansel's work for Meccano); and Darling, "Special Educational Apparatus," p. 79. On the wider social setting see Harry Hendrick, *Children, Childhood, and English Society, 1880–1990* (Cambridge: Cambridge Univ. Press, 1997), pp. 88–89.

[23] Darling, "Special Educational Apparatus," p. 79.

[24] William Hodson Brock, ed., *H. E. Armstrong and the Teaching of Science, 1880–1930* (Cambridge: Cambridge Univ. Press, 1973), pp. 55–73, 111 (quotation); and Jenkins and Swinnerton, *Junior School Science Education* (cit. n. 4), p. 25 (quoting Hadow Committee report). Sir Henry Hadow chaired six consultative committees between 1923 and 1933 that investigated various aspects of British education, from books to psychological tests to the curriculum itself. The 1931 Hadow Committee report analyzed primary education; it can be found online at Derek Gillard's *Education in England* page: http://www.dg.dial.pipex.com/documents/hadow/31.shtml. Alongside its recommendation of "activity and experience" was the claim that an ideal elementary school consisted of "a community of young and old, learning together." See also P. Atkinson and S. Delamont, "Mock-ups and Cock-ups: The Stage-Management of Guided Discovery Instruction," in *The Process of Schooling: A Sociological Reader,* ed. M. Hammersley and P. Woods (London: Open Univ. Press, 1976), pp. 133–142, esp. pp. 133–134.

The continuities between a heuristic mode of teaching and campaigns for "general science" have not usually been recognized, yet both endorsed a discovery-driven, historically based pedagogical process. Construments connected these two contemporary concerns: as well as being intended for domestic use, they were designed to challenge the perceived excessive specialism of school syllabuses. Thus, in a preface to the *Construments Manual of Experimental Science,* published in 1935 by J. Harold Getliffe, Hansel's assistant at Bedford School, Hansel urged that the "importance of teaching General Science cannot be overemphasised." Many reports and articles in these years advocated a broadening of science curricula in senior schools and encouraged a "problem-method" approach to the teaching of science. For example, writing about a 1932 educational pamphlet entitled *General Science* in the *School Science Review,* Henry Stanley Shelton, who would later write *Thoughts of a Schoolmaster* (1934), argued that the position of modern science was such that "every educated person should be, in some degree, acquainted both with the facts and with the methods by which they have been discovered. In whatever subjects they may specialise in the later years of school life, whatever their calling in after years, all should have a slight acquaintance with some of the outstanding facts and theories of modern science."[25] Like Hansel, Shelton argued that a broad scientific education should precede further specialized study, whether in the sciences or in any other discipline. However, Hansel believed that communicating "facts and theories" was not enough: one should be training children in the practical skills of building and using instruments to provide a truly scientific education.

Construments sets and the *Construmag* attempted to actualize the aims of contemporary educational generalists: "To enable the possessor of a Construments Outfit to realise the enormously wide range of scientific activity within his grasp the *Construmag* has been issued to explain how Construments may be employed in scientific research . . . the *Construmag* will not confine its activities to optics but will deal with every branch of Science and Industry."[26]

The outfits, though in their initial form dedicated to optical instruments, were likewise designed to impart a generalized scientific education. The company claimed that "the microscope and the camera are not merely optical instruments. They are instruments for use in all manner of scientific subjects." The outfits did contain remarkably flexible apparatus with a variety of possible uses: one promotional leaflet juxtaposed crystal-sketching, "live-box" making, "a talk about lenses," and Morse code as "a few more things that Construments help you to understand." Contemporary consumers realized this as well: responding to the company's rhetoric about introducing children to a wide range of activities, Edward Blackwell's father purchased the "educational toy" "to encourage an interest in scientific subjects other than chemistry."[27]

Construments users were thus urged to be creative in their applications of the apparatus—to address a wide range of problems and thereby obtain a generalized education suitable for many subsequent careers. Hansel had lamented the lack of creativity in con-

[25] See Anna-Katherina Mayer, "Roots of the History of Science in Britain, 1916–1950" (Ph.D. diss., Univ. Cambridge, 2003), pp. 11–55; Hansel, "Preface," in Getliffe, *Construments Manual of Experimental Science* (cit. n. 12), pp. iii–iv; Henry Stanley Shelton, rev. of *General Science, School Science Review,* 1933, *14*:459–460; and Shelton, *Thoughts of a Schoolmaster (or Common Sense in Education)* (London: Hutchinson, 1934). On contemporary trends regarding the teaching of science see Jenkins, *From Armstrong to Nuffield* (cit. n. 4), pp. 84–90.

[26] *Construmag,* Feb. 1933, p. 1.

[27] *Construmag,* Feb. 1933, p. 1; Construments promotional leaflet, p. 8; and Blackwell, *Unfolding Years* (cit. n. 1), p. 135.

temporary educational practice: "too often the student is supplied with apparatus which suggests or even prescribes for him his method of experimenting and leaves nothing to his originality or resource." The opening editorial of the *Construmag,* perhaps written by Hansel himself, mirrored this attitude, as it "invited all readers . . . to make this magazine of practical science not only a success but a stimulus to originality and resource." Construments instruction manuals stressed that "there is ample scope for experiment in Construments, and users should try various arrangements and novelties of their own." The *Construmag* even gave prizes to those who created new instruments out of Construments components. Here Hansel's views diverged from heuristic modes of pedagogy in which pupils were guided toward a known solution; instead, he stressed the many possible solutions Construments outfits invited. His sets embodied the creativity of the scientific enterprise, a concept that was often emphasized during the so-called neglect of science debate early in the twentieth century: for example, a British Association for the Advancement of Science report of 1917 had urged scientific educators to appeal to the imagination of budding scientific geniuses. Construments therefore formed part of a movement that attempted to uphold and promote the education of all children in the sciences: scientific literacy was perceived as crucial to the future of the nation—not just for those who would be seeking a technical education, but also for boys and girls who wished to go into more stereotypically artistic or creative careers. The popular contemporary magazine *Armchair Science* had emphasized the importance of an acquaintance with scientific knowledge for inhabitants of the twentieth century, claiming in its opening editorial of April 1929 that the publication was "intended . . . for the table of every home," to be read by "every man, woman and intelligent child."[28]

PLAYING AT DETECTION

As well as training children through play in the physical construction of optical instruments, Construments sets were intended to develop mental skills, imparting the generalized scientific training Hansel claimed was necessary for every child: the sets were advertised as enabling "boys and girls to make numerous optical instruments, and so develop the scientific mind in modern youth." Enhanced mental skills were thus irretrievably linked to the bodily skills imparted as Construments stimulated "research, initiative, education, ingenuity and inventiveness." Earlier in the century, Meccano sets had aimed to address similar concerns; for example, the instruction booklet issued with the first sets in 1901–1902 announced the intention to "[train] the young in mechanical construction." The introduction continued:

> Everyone must have recognised how full of interest to a child's mind is "the building up of an object"; how hour after hour has been pleasantly spent in childish attempts to make models of things which have attracted his attention. If then this bend of its mind can be turned into the right groove, an educational process has been commenced which may, later on, prove of great benefit. . . .
>
> Upon examination it will be found this invention will help to train the . . . child's mind on these lines: chaos will give way to order: a hazy conception to a definite idea: guess work to

[28] Hansel, "Suggestions Relating to Reform in the Teaching of Geometrical Optics" (cit. n. 12), p. 271; *Construmag,* Feb. 1933, p. 1; Construments Instruction Book, p. 16; and "'Ourselves': What We Are and What We Hope to Be" [editorial], *Armchair Science,* Apr. 1929, p. ii. On the "neglect of science" debate see Mayer, "Roots of the History of Science in Britain" (cit. n. 25), pp. 18, 50.

> accuracy: while at the same time the various parts will give endless scope to the constructive abilities of either a child or a grown-up person.[29]

Both companies appealed to children's creative and constructive ideals of play, yet also imparted a rigorous education in skills of mechanical manipulation and mental skills of order and accuracy.

Even the seemingly most disparate contents of the *Construmag* reinforced Construments' educational message. For example, Capt. Frederick Annesley Michael Webster, a prolific author of boys' books, contributed many detective tales that stressed the continuities between the processes of detection, the everyday activities of criminologists, and the practice of using a Construments kit. A story entitled "Detection from a Distance" offered the following observation: "[the weapon] had been examined for finger-prints under the latest pattern microscope—this, of course, could have been done just as well by the type of microscope you can construct from your Construments set—but had yielded no result." Later on, the narrator noted that "incidentally, there was nothing on the professor's list that is not contained in the Construments chemical sets, so that the reader of this article, if he has a liking for scientific crime research work could, at small cost to himself, have carried out any of the experiments connected with the solution of the particular crime we are considering." Just as Construments users mimicked the practice of detectives, the police force investigators were urged to act like scientific boys and girls: "Why, even the use of so simple and so inexpensive an apparatus as comprises a Construments set, placed in the hands of a knowledgable [*sic*] constabulary, educated in the elementary principles of the use of the microscope, the spectrascope [*sic*] and such like, would lead to the early identification of finger-print, fire, and blood clues, and would hasten the process of bringing to book the perpetrator of a crime."[30]

Moreover, the scientific skills of observation and deduction, meant to be inculcated by engagement with a Construments outfit, were the two faculties most prized in the *Construmag*'s detective fiction, as in this example taken from Webster's serialized narrative "Caleb Causes Trouble":

> "My hat" exclaimed Hallowes, genuinely impressed. "That's pretty brainy. I mean to say Sherlock Holmes and all those fellows couldn't have done better."
>
> "Reckon it's easy when you know how" declared Caleb grandly. . . . "I have trained myself to observe and dee-duct. . . . I guess observation and dee-duction are the cats' whiskers, the whale's fodder, *and* the canary's pyjamas. . . ."
>
> "You're going to be a detective?"
>
> "You've said it. I sure am."[31]

In these ways the journal emphasized the power of Construments' practical scientific education to train the mind. The rhetoric of detective fiction, which emphasized the rational processes of reasoning followed to reach a logical conclusion as to who committed a crime, was invoked by writers like Webster to demonstrate the similarity of these mental processes to scientific skills inculcated through using a Construments set.

Other writers and educators had highlighted the similarity between criminological in-

[29] Construments advertisement, *Construmag,* Nov. 1933, p. iii; Construments promotional leaflet, p. 1; and Love and Gamble, *Meccano System* (cit. n. 22), p. 16.

[30] *Construmag,* Dec. 1933, p. 260; and *ibid.,* Nov. 1933, p. 231.

[31] *Ibid.,* Feb. 1934, p. 311.

vestigation and learning the sciences. For example, Armstrong's heuristic educational methods had also been compared to the process of detection, designed to train the "powers of reasoning and observation." Thus, in response to criticism ridiculing the "impossibility of making the student discover everything for himself," Armstrong countered that "no one asks that he should or believes that he can: only that he shall learn how discoveries are made, first by children, then by ordinary detectives, then by discoverers proper. Always something noteworthy is first observed—then the chase begins."[32] As in the *Construmag* stories, "detectives" mediated between the worlds of "children" and "discoverers proper."

This criminological emphasis might seem rather surprising: traditionally, educators have tended to employ and impart the most orthodox and established of scientific facts. Moreover—and this was emphasized by heuristic reformers like Armstrong—the development of the individual's proficiency in the sciences was supposed to recapitulate the development of the sciences themselves.[33] The emphasis, for example, on the "New 'Craze': Collecting Finger-Prints in Your Own 'Scotland-Yard' Albums" would contradict this historical approach to education, also found in the *Construmag.* On the other hand, such content demonstrates Construments designers' concern with the processes of mental reasoning strengthened through bodily interaction with instrumentation and with the wider benefits of a general scientific education that would render children, as they put it, "abnormally inquisitive." Of course, the company also exploited a popular phenomenon of the time in order to boost sales: juvenile detectives featured prominently in contemporary children's magazine stories for both boys and girls, and Richmal Crompton's collection entitled *William—The Detective* was first published in 1935. Armstrong himself had noted that "children are delighted to be . . . told that they are to act as a band of young detectives" and that they could be enthused about the sciences in this way.[34]

Writing in the *School Science Review* of March 1935, the renowned educator Sir William Hamilton Fyfe, Principal of Queen's University, Kingston, Ontario, reinforced these ideals, arguing that in focusing on imparting factual information scientific education had, ironically, "been unscientific, because it has deserted the scientific path of personal observation and experiment." Fyfe advocated "bringing pupils into direct contact with phenomena," "allowing them to grow minds through the process of finding their own formulae." Attempting to defend heuristic modes of teaching, he argued for the importance of mental skills developed through this active, unmediated bodily process: in education "what matters is the method of science, the attitude of mind, the appreciation of truth."[35] It could certainly be argued—and the makers of Construments made the point explicitly—that a scientific education that developed such widely applicable cognitive skills was appropriate for every boy and girl. Such an education depended on the successful construction of instruments using the set's components and its instructional apparatus, and it is to these topics that I now turn.

[32] Mayer, "Roots of the History of Science in Britain" (cit. n. 25), p. 28; and Brock, *Armstrong and the Teaching of Science* (cit. n. 24), p. 73.

[33] Atkinson and Delamont, "Mock-ups and Cock-ups" (cit. n. 24), p. 142.

[34] Construments promotional leaflet, p. 3 ("New 'Craze'"); *Construmag,* Apr. 1934, p. 28 ("abnormally inquisitive"); Richmal Crompton, *William—The Detective* (1935; London: Armada, 1978); and Brock, *Armstrong and the Teaching of Science* (cit. n. 24), p. 113. See also Kirsten Drotner, *English Children and Their Magazines, 1751–1945* (New Haven, Conn./London: Yale Univ. Press, 1988), pp. 206–207, 218–219.

[35] William Hamilton Fyfe, "Science in Secondary Education," *School Sci. Rev.,* 1935, *16*:289–297, on pp. 291, 294.

BUILDING INSTRUMENTS

As celebrated in the company's promotional material, Construments provided the consumer with the opportunity to build his or her own scientific instruments; but as with other contemporary technologies, such as developing photographs or "radio-hobbying," the user was expected to possess a certain degree of skill in order to use and enjoy the newly purchased equipment. However, as Construments were specifically designed to provide an introduction to the instrumentation and researches of the scientist, these skills themselves needed to be developed and their discovery guided: as the introduction to the *Construments Manual of Experimental Science* warned, "the handling of the children's sets may offer some initial difficulty." Bodily disciplining, such as that required with the adoption of novel electrical technologies in the late nineteenth century, has been recognized as fundamental to the sociology of childhood and the nature of play in general. Similarly, Construments children's sets forced the user to undergo bodily interaction with instruments and the sciences: the physical skills of mechanical manipulation, from securing lenses in kaleidoscopes to screwing pieces of metal together, were acquired by building models.[36]

The instruction manual contained within each Construments kit, or purchased separately (see Figure 3), guided this bodily interaction by detailing the steps required to create each of the different models. It set out rules according to which the instruments could be created—despite Hansel's stress on permitting a greater "creativity" in educational processes—and guided children through the building experience: the process was split into discrete stages and explicitly narrated. The opening pages of the instruction manual recapitulated Hansel's notion that an introduction to universal skills should precede the development of specialized capabilities. Before the child could decide which instrument to construct, she was confronted with a section entitled "How to Identify Your Construments Parts" that featured large, clear pictures of the different component parts, each with its corresponding number; this was followed by a series of "useful suggestions" and then an articulation of the skills most commonly required when using Construments components, such as fixing lenses in tubes with lens holders. After this training in the general principles of putting together mirrors, screws, nuts, and the instrument stand, the reader was presented with sparsely annotated diagrams of the different models. Thus, the instruction book deliberately used images to impart information about how the instruments should be constructed, claiming that "in most cases the reader will be able to assemble any of the Instruments shown, simply on sight of the diagrams. To make everything as clear as possible, however, references are made back to the various 'Fitments.'"[37] Users might have to turn back a few pages to relearn a particular skill.

The construction of the sets therefore mimicked in miniature the process of a Construments education, progressing from an introduction to general skills via a reenactment of standard experiments to the independent construction of and investigation into scientific theory and instrumentation. The outfits, and supplementary material such as the *Construments Manual of Experimental Science,* were designed "to train the reader to explore the subject of optics for himself. He will not be content to read about optical effects, but he

[36] Getliffe, *Construments Manual of Experimental Science* (cit. n. 12), p. v. On bodily disciplining see Carolyn Marvin, *When Old Technologies Were New: Thinking about Electronic Communication in the Late Nineteenth Century* (Oxford/New York: Oxford Univ. Press, 1988), pp. 109–113; and Chris Jenks, ed., *The Sociology of Childhood: Essential Readings,* rpt. ed. (Aldershot: Gregg Revivals, 1997), pp. 203 (with regard to new electrical technologies), 76–86 (on building models).

[37] Construments Instruction Book, p. 16.

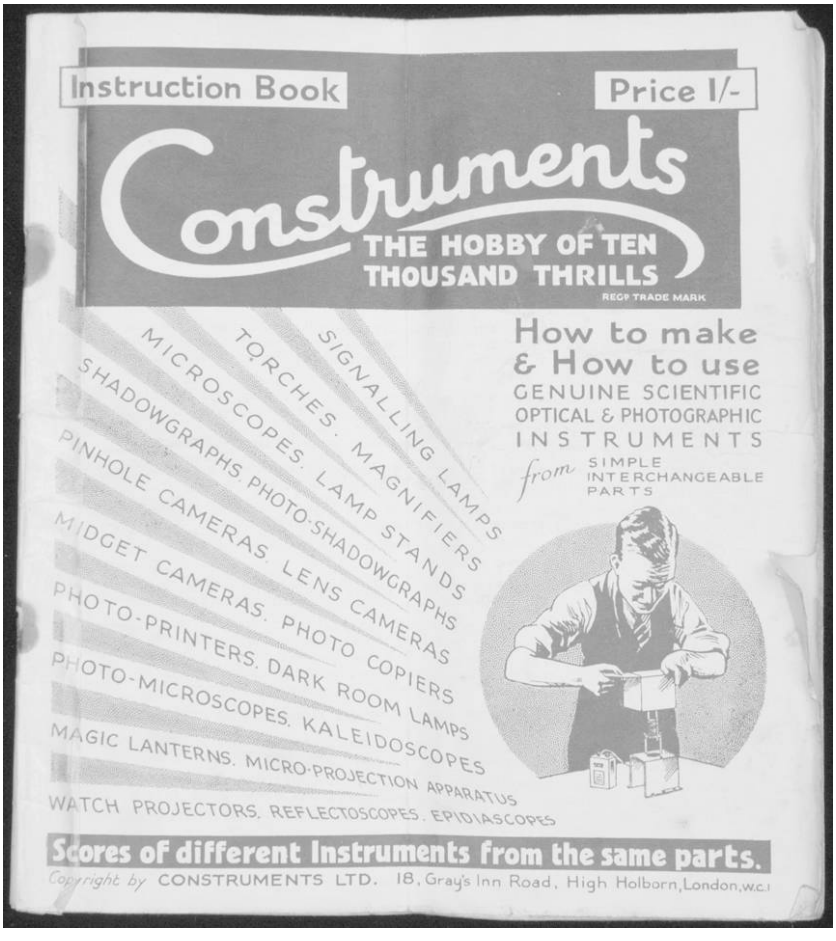


Figure 3. *Cover of the Constructments instruction book, depicting a boy using the Constructments set and detailing the instruments that could be constructed. (From author's collection.)*

will be able to construct the necessary optical apparatus and instruments to conduct experimental work and thereafter proceed to that most entertaining and adventurous domain of individual research."[38] The sets were a necessary prerequisite to unconstrained scientific investigation.

However, children sometimes encountered problems when attempting to construct Constructments models: as Frank Hanby commented, in the "100" outfit "instrument 84 needs 4 plano-convex Lenses against the 3 included in the set." This problem was, in fact, noticed by the company, and the following announcement appeared in the June 1933 *Construmag*: "It has been pointed out that Model 84 . . . requires four plano-convex lenses whereas there are only three in the '100' outfit. It will be found that the Bi-Convex Lens (17) may be substituted for one of the Plano-Convex Lenses (18) of the Objective." The wider Constructments community, as embodied in the *Construmag,* could help overcome

[38] Hansel, "Preface," in Getliffe, *Constructments Manual of Experimental Science* (cit. n. 12), p. iv.

problems that might arise. The journal could also disseminate information from manufacturer to consumer and was hence a means of facilitating communication between different members of the heterogeneous Construments community. Communication was also facilitated because the names and numbers of parts and instruments, as well as the parts themselves, were standardized across the Construments sets: as with systems such as Meccano, the outfits were intended to complement each other. Moreover, purchasers of Construments sets were encouraged to subscribe to the *Construmag* to get information on new models that could be constructed: "Useful Suggestion 8" of the instruction book was "Interest your friends in Construments and the *Construmag.*"[39] The *Construmag* often contained experiments to conduct with Construments, particularly in the first issues, and its diagrams and numbering system were continuous with those found in the instruction books; hence, the magazine often served as an instruction book itself. Moreover, the new models sent in by readers were given numbers at the end of the sequence of Construments inventions: their suggestions became part of the company's product line and were incorporated into the outfits.

Thus a group of other users, a teacher, or the *Construmag* could all contribute to a child's learning how to read the instruction manual, uncover its tacit assumptions, and solve problems; the rules of the book themselves required skill in their making and use. The process of heuristic education has been likened to an "information-game" that proceeds according to certain tacit rules and is skillfully guided by the educator. Armstrong, for example, claimed that it was "of importance that [both pupils and teachers] be taught the rules of the game of discovery and learn to play it skilfully." Using a Construments set, therefore, was a means of learning the rules crucial to guided discovery. These constant references to "play" and "games" unveil the illusory nature of heuristic discovery methods: positioning children's discoveries between the "real" world of scientific discoveries and the "imaginary" world where they recapitulated discoveries *as if* they were scientists reflects wider notions about childhood as lived between these real and imaginary realms. This hybrid world is one of play, in which every boy and girl really could be a scientist: in their recreation children "recreated" their society. Thus science is "rooted in the primeval soil of play," and it is through playing that the training of scientific skills can be effectuated.[40]

These continuities between the equipment and experience of playing and experimenting can be traced in other contemporary contexts as well. Plasticine was both a toy modeling material and a sealant for vacuum seals in the Cockcroft-Walton accelerator project, supplied by Metropolitan-Vickers to the Cavendish laboratory in Cambridge. Jeff Hughes has shown how Cavendish research at this time also depended on "off-the-shelf" components such as valves that were manufactured for the recreational radio industry. Construments sets similarly augmented and complemented the 1920s trend for utilizing standardized components to construct wireless sets from scratch at home; one contemporary magazine even called radio a "toy" for men. As the same equipment was used in toy sets, in industrial machinery, and for academic research, children could become part of these interconnected scientific communities by playing at building instruments.[41]

[39] Frank Hanby, in *Other Systems Newsletter,* [1992?], *5,* p. 79; *Construmag,* June 1933, p. 90; and "10" Instruction Book, p. 6.

[40] Brock, *Armstrong and the Teaching of Science* (cit. n. 24), p. 111; and Huizinga, *Homo Ludens* (cit. n. 6), p. 23. See also Atkinson and Delamont, "Mock-ups and Cock-ups" (cit. n. 24), pp. 138, 136; and Jenks, ed., *Sociology of Childhood* (cit. n. 36), pp. 80, 195.

[41] Hendry, introduction to "Part 3: Underlying Themes" (cit. n. 17), p. 121; and Hughes, "Plasticine and Valves" (cit. n. 16), pp. 61, 66, 67, 79.

CONSTRUMENTS COMMUNITIES

The first issue of the *Construmag* —the "Official Journal of Constructments"—was published in February 1933 and sold for 6d (see Figure 4). The magazine included a diverse range of articles on biology, astronomy, sport, magic, criminology, and chemistry, as well as mathematical puzzles and stories, and was published monthly or bimonthly until being discontinued in April 1934. It aimed at educating but also entertaining and interesting children in science and investigation into the natural world, and, like the Constructments outfits themselves, it was hailed as a novel enterprise. However, during the interwar years children's commercial magazines, comprising a miscellany of stories, including school, detective, adventure, and science fiction, and often highly illustrated, were in fact commonplace. Children's periodicals covering scientific knowledge had been popular since the 1830s, when works such as the *Youth's Magazine* communicated scientific knowledge to their readers. The *Construmag* was not as innovative as it claimed but, rather, a part of

Figure 4. *The cover of the first issue of the* Construmag, *February 1933, "a magazine of home science, entertainment and experiment." (From British Library classmark P.P.1447.bbf, Vol. 1, no. 1, 1933, front page. © The British Library. All rights reserved.)*

this undoubtedly popular genre: in 1933 half of all pupils aged eleven to fifteen read more than three comics a week. Indeed, the circulation of the *Meccano Magazine* peaked at seventy thousand in 1930. While at the *Meccano Magazine,* Hawks had been criticized for converting its content from descriptions of models to something like the *Boy's Own Paper*: "all jolly hockey-sticks and spiffing yarns!" Apparently readers "actually wanted to see MECCANO featured in a *Meccano Magazine* and far less on 'Wireless, adventure stories and magic-lantern lecture reports!'"[42] The *Construmag,* closely resembling a hybrid between a dry description of models and precisely those articles for which the *Meccano Magazine* had been attacked, could therefore have been the magazine Hawks had intended to publish all along. By conforming to such traditions, and presenting puzzles and stories as well as Construments reports, advertisements, and editorials, the journal capitalized on contemporary children's interests; but it was also a means of identifying the members of a Construments community.

This virtual community, bounded by the possession of a Construments outfit and readership of the *Construmag,* could become an actual community through the creation of a Construments Club, of the sort applauded by the *Construmag* in the spring of 1933:

> We congratulate the members of Holy Trinity Boy's Club, Barnsbury, N., on the formation of a Construments Section. . . .
>
> There is little doubt that clubs . . . have been responsible for great advancement in knowledge and progress of mankind, by the pooling of information and the mutual exchange of ideas. Many of our distinguished societies such as the Royal Society, and the British Association for the Advancement of Science had their inception in quite humble and often obscure surroundings.

The explicit comparison to the Royal Society and the British Association was typical of the company's grandiose promotional rhetoric and supported Construments' claim to provide "handsome and imposing instruments which everybody is proud to use." Other contemporary users formed their own groups: Edward Blackwell formed his Construments Club in 1935; and Robert Blyth established the United Science Club, unconsciously echoing in the name of the group Hansel's stress on connecting the sciences, imparting generalized skills. Though the emphasis in academic analyses of play and development has been on individual interactions with material objects such as toys, this stress on the communities formed around the optical kits reveals how important group learning could be. Construments seem to have inspired the formation of the clubs but not to have been the sole determinant of their activities. For example, Blackwell's Construments Club listened to lectures on dynamos and electric motors, as well as having "a lot of fun" experimenting with Construments and other homemade equipment; as he remembered,

> experiments to use metallic sodium as a propellant for miniature cardboard motor boats produced an explosion that left its mark on the ceiling. . . . Someone, trying to steer the wildly careering object, used a metal probe, forgot the danger of sparks, and, whoosh, the hydrogen . . . blew the contents of our container up in the air. No one was hurt, but my father, who rushed in, saw five very white faces round the kitchen table.

[42] Topham, "Periodicals and the Making of Reading Audiences for Science" (cit. n. 3), p. 57; Drotner, *English Children and Their Magazines* (cit. n. 34), pp. 183, 188, 190 (comics); and Joseph Manduco, *The Meccano Magazine, 1916–1981* (London: New Cavendish Books, 1987), pp. 7 (circulation figures), 6 (on readers' complaints). At this time, and despite a ban on editors appending personal names to articles, Hawks also used the *Meccano Magazine* to advertise his numerous literary productions, described as books "from the Editor" (*ibid.,* p. 7). His works do not appear to be advertised in the *Construmag,* however.

Blyth's United Science Club similarly "had tendencies . . . of an explosive nature." Owning a Constructions set could be the first step in becoming a member of a scientific community; references to the *Construmag* as a "journal" reinforced this notion of Constructions as a scientific institution with its own publications. As the opening editorial proclaimed: "the *Construmag* will provide a medium of universal expression of opinion, and exchange and presentation of views on experimental science which has hitherto been denied."[43] The novelty and universality of the Constructions enterprise were closely connected, as Hansel aimed to allow every boy and girl access to a scientific society.[44]

One striking element of the Constructions rhetoric was this insistence on "every boy and *girl*" becoming scientific, an emphasis that belies the presentation of the interwar sciences as an increasingly and exclusively masculine preserve. The sets were intended to involve both sexes, and there is some evidence from the *Construmag* that girls did form part of this heterogeneous Constructions community: for example, in March 1934 Margery Elliott, aged fourteen, from Edgbaston, Birmingham, contributed the design for a "new model kaleidoscope." Some articles in the magazine were perhaps addressed to a male readership, yet others appealed to girls—for example, an account by the Duchess of Bedfordshire of a solo flight. The packaging of the outfits (see Figures 1 and 2) clearly depicted both boys and girls using the instruments, as the company attempted to appeal to all children, reinforcing its democratizing aims as well as, more pragmatically, doubling its target market. The early Meccano sets had similarly illustrated their boxes with drawings of both boys and girls, yet by the interwar period these sets were subtitled "Engineering for Boys." Constructions would seem to go against this trend, seen in the late nineteenth and early twentieth centuries, of increasing provision of gender-specific toys. For example, Carroll W. Pursell, Jr., emphasizes the separation between the types of toys promoted and bought for male and female children in interwar America: construction kits for boys, domestic appliances for girls.[45]

In addition to creating new communities, however, Constructions were advertised as being "ideal from the point of view of interesting Scientific and Photographic Societies, Field Clubs, Scout Troops, etc., in many branches of popular science": existing communities could be incorporated into the Constructions microcosm by possessing its technology. Numbers of scouts and guides reached an interwar peak in 1933, and the movements began to be based around the study of nature and outdoor activities. Furthermore, existing annuals detailed the scientific principles of novel technology such as the radio and communicated useful information about how best to construct wireless sets at home.[46] Con-

[43] *Construmag,* Mar.–Apr. 1933, p. 50; Constructions promotional leaflet, p. 6; Blackwell, *Unfolding Years* (cit. n. 1), pp. 135, 136; Robert Blyth, "An Interesting Social Survey of the Twentieth Century and an Entertaining Read" [rev. of Blackwell, *Unfolding Years*], *Pharmaceutical Journal,* 2004, *272*:516; and *Construmag,* Feb. 1933, p. 1. See also Brian Sutton-Smith, "Does Play Prepare the Future?" in *Toys, Play, and Child Development,* ed. Goldstein (cit. n. 6), pp. 130–146, esp. p. 141. Unlike Blackwell, Blyth did go on to have a scientific career after a youth spent playing with Constructions sets, and he edited the *Pharmaceutical Journal* from 1961 to 1986.

[44] A century earlier, the *Youth's Magazine* had "frequently represented social practices of conversation, family reading, and family recreation as being of great importance," not only to communicate its evangelical piety, but also as a means of education. See Topham, "Periodicals and the Making of Reading Audiences for Science" (cit. n. 3), p. 65.

[45] *Construmag,* Mar. 1934, p. 28; Robert Opie, *Remember When: A Nostalgic Trip through the Consumer Era* (London: Mitchell Beazley, 1999), pp. 38 (1908 Meccano set), 71 (later 1920s "Engineering for Boys" sets; copy of the *Meccano Magazine* cover for Jan. 1924, subtitled "Published in the Interests of Boys"); and Pursell, "Toys, Technology, and Sex Roles in America, 1920–1940" (cit. n. 2). For nineteenth-century examples of the provision of gender-specific toys see Calvert, *Children in the House* (cit. n. 5), pp. 110–119.

[46] Constructions promotional leaflet, p. 2; Drotner, *English Children and Their Magazines* (cit. n. 34), pp. 198–199 (nos. of scouts and guides); and Hughes, "Plasticine and Valves" (cit. n. 16), p. 68 (wireless sets).

struments outfits were therefore marketed to a large juvenile audience that was already interested in "nature study" and construction; the company later attempted to capitalize on these other movements that were seeking to increase the profile of scientific education in schools—for example, by bringing out "field naturalist" outfits. In interwar Britain, an increase in leisure activity was complemented by increasing commercialization, as many clubs associated with a particular consumer product were created for children. Thus, the "League of Ovaltineys" was formed in 1935 as a response to Radio Luxemburg's *Ovaltiney Concert Party,* which was sponsored by Wonderfood, Ovaltine's manufacturers; membership in the club reached five million by the end of the decade. Similarly, the Lines Brothers toy company established a "Frog Club" for enthusiasts of their "Frog" series model airplanes in June 1933.[47] These groups mirrored the Construments clubs: they were children's communities united by possession of a common product and knowledge of a certain brand name.

As well as being a means of advertising and promoting products, these clubs were also spaces where skills could be pooled: photographers could share developing facilities, experienced radio or model airplane builders could help those who were "hobbying" for the first time. Amateur radio magazines shared the experiences of the "*cognoscenti* "; for many contributors, such exchanges marked the beginnings of a scientific career. Similar communal aims can be perceived in the *Construmag.* Readers wrote in to share their skills in producing new instruments, there was an attempt to set up an exchange of secondhand parts, and some Construments users were inspired to further scientific study: Blackwell, for example, proceeded to a Demyship Scholarship in Natural Science at Magdalen College, Oxford, and hoped to be a biochemist. Such a mix of participants, in terms of age and knowledge, in the Construments clubs was crucial if the sets were both to be interesting and to work: as Blackwell remembered, "the idea" of Construments "was good but we were not really mathematically advanced enough to use the equipment, as might have been the case a year or two later when we could have handled the optical equations required. However, by then the equipment would have been inadequate for what we would have wanted to do."[48]

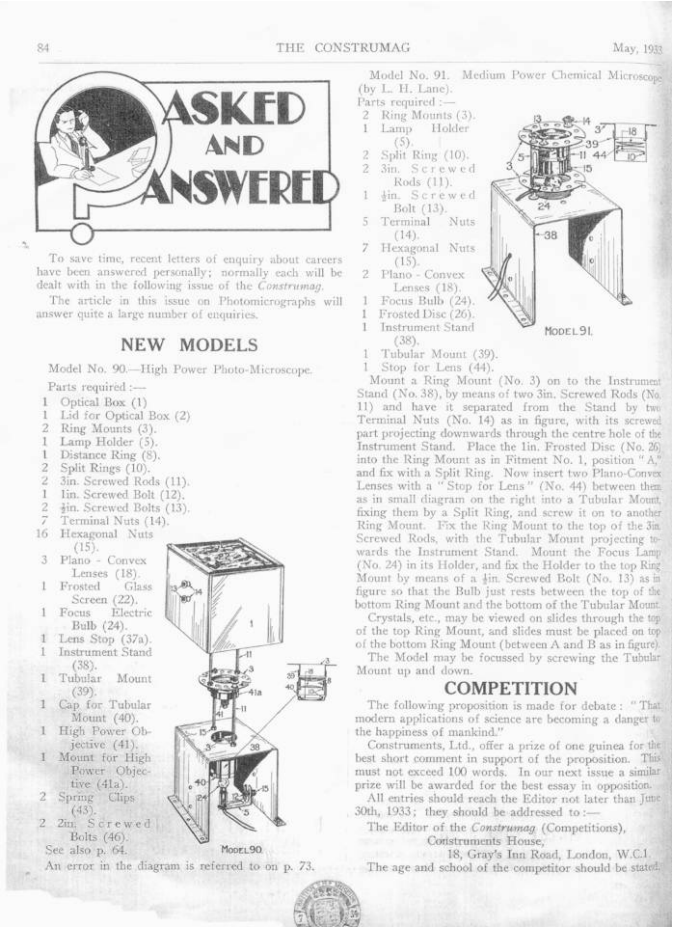
Hansel's son, Charles Edward Mark Hansel, himself confessed that for more advanced children the sets were "a bit boring in places."[49] Encouraging the formation of Construments communities thus helped circumvent problems younger children might have had in constructing the instruments and retained the interest of their elders, who might otherwise have desired a more sophisticated or elaborate model.

Construments clubs on both small and large scales were heterogeneous, encompassing children and many different adults: parent, teacher, publisher, manufacturer. The "Asked and Answered" letters page at the end of the magazine encouraged dialogue between different members of the community and emphasized participation, with competitions being run and prizes awarded (see Figure 5). The presence of more highly skilled or knowledgeable individuals within the Construments "club" therefore facilitated guided discoveries crucial for education and the construction of Construments instruments: they

[47] On the "League of Ovaltineys" see Hendrick, *Children, Childhood, and English Society* (cit. n. 22), p. 89; and Opie, *Remember When* (cit. n. 45), p. 82. On the "Frog Club" see Brown, *British Toy Business* (cit. n. 11), p. 133. More generally, on the association of children's clubs with consumer products see S. G. Jones, *Workers at Play: A Social and Economic History of Leisure, 1918–1939* (London: Routledge & Kegan Paul, 1986), pp. 9, 34–61.

[48] Hughes, "Plasticine and Valves" (cit. n. 16), p. 68; and Blackwell, *Unfolding Years* (cit. n. 1), p. 135.

[49] C. E. M. Hansel, personal communication, 7 June 2005.



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ASKED AND ANSWERED

To save time, recent letters of enquiry about careers have been answered personally; normally each will be dealt with in the following issue of the *Construmag*.

The article in this issue on Photomicrographs will answer quite a large number of enquiries.

NEW MODELS

Model No. 90.—High Power Photo-Microscope.

Parts required :—

1 Optical Box (1)
1 Lid for Optical Box (2)
2 Ring Mounts (3).
1 Lamp Holder (5).
1 Distance Ring (8).
2 Split Rings (10).
2 3in. Screwed Rods (11).
1 1in. Screwed Bolt (12).
2 ¼in. Screwed Bolts (13).
7 Terminal Nuts (14).
16 Hexagonal Nuts (15).
3 Plano - Convex Lenses (18).
1 Frosted Glass Screen (22).
1 Focus Electric Bulb (24).
1 Lens Stop (37a).
1 Instrument Stand (38).
1 Tubular Mount (39).
1 Cap for Tubular Mount (40).
1 High Power Objective (41).
1 Mount for High Power Objective (41a).
2 Spring Clips (43).
2 2in. Screwed Bolts (46).

MODEL 90

See also p. 64.

An error in the diagram is referred to on p. 73.

Model No. 91. Medium Power Chemical Microscope (by L. H. Lane).

Parts required :—

2 Ring Mounts (3).
1 Lamp Holder (5).
2 Split Ring (10).
2 3in. Screwed Rods (11).
1 ¼in. Screwed Bolt (13).
5 Terminal Nuts (14).
7 Hexagonal Nuts (15).
2 Plano - Convex Lenses (18).
1 Focus Bulb (24).
1 Frosted Disc (26).
1 Instrument Stand (38).
1 Tubular Mount (39).
1 Stop for Lens (44).

MODEL 91.

Mount a Ring Mount (No. 3) on to the Instrument Stand (No. 38), by means of two 3in. Screwed Rods (No. 11) and have it separated from the Stand by two Terminal Nuts (No. 14) as in figure, with its screwed part projecting downwards through the centre hole of the Instrument Stand. Place the 1in. Frosted Disc (No. 26) into the Ring Mount as in Fitment No. 1, position "A," and fix with a Split Ring. Now insert two Plano-Convex Lenses with a "Stop for Lens" (No. 44) between them as in small diagram on the right into a Tubular Mount, fixing them by a Split Ring, and screw it on to another Ring Mount. Fix the Ring Mount to the top of the 3in. Screwed Rods, with the Tubular Mount projecting towards the Instrument Stand. Mount the Focus Lamp (No. 24) in its Holder, and fix the Holder to the top Ring Mount by means of a ¼in. Screwed Bolt (No. 13) as in figure so that the Bulb just rests between the top of the bottom Ring Mount and the bottom of the Tubular Mount.

Crystals, etc., may be viewed on slides through the top of the top Ring Mount, and slides must be placed on top of the bottom Ring Mount (between A and B as in figure).

The Model may be focussed by screwing the Tubular Mount up and down.

COMPETITION

The following proposition is made for debate: "That modern applications of science are becoming a danger to the happiness of mankind."

Constructors, Ltd., offer a prize of one guinea for the best short comment in support of the proposition. This must not exceed 100 words. In our next issue a similar prize will be awarded for the best essay in opposition.

All entries should reach the Editor not later than June 30th, 1933; they should be addressed to :—

The Editor of the *Construmag* (Competitions),
Constructors House,
18, Gray's Inn Road, London, W.C.1.

The age and school of the competitor should be stated.

Figure 5. *The "Asked and Answered" letters page of the* Construmag, *May 1933. (From British Library classmark P.P.1447.bbf, Vol. 1, no. 3, 1933, p. 84. © The British Library. All rights reserved.)*

could impart the consumer skills that were tacitly required and yet not specifically mentioned in the instruction booklets. It was only in such a community that "younger people can 'play' with Constructors. Older ones can use it educationally. And you can get the most fascinating and spectacular results."[50]

CONCLUSION

Unlike Edward Blackwell, children growing up after World War II would probably not have been able to receive a new Constructors set for Christmas: Constructors Ltd. appears on the London Guildhall Library's list of dissolved companies for 1949 and had disappeared from Kelly's London Directory in 1937. Although I have unfortunately been unable to obtain direct records, it seems as though the company struggled to survive the war years, perhaps owing to legislation, effective from 1 January 1942, that forbade the

[50] Constructors promotional leaflet, pp. 5–6.

production of metal toys. At this time, Constructments' manufacturer, the British Thomson-Houston Company, had seen its output overtaken by military concerns, including the provision of parts for RAF fighter aircraft and the development of radar technologies.[51] Indeed, users of Constructments themselves seemed to terminate their stories with reference to the war: Robert Blyth connected the development of his scientific skills with his work as a "fire control" operator and with the detonation of the atomic bombs over Japan.[52]

Bounded by the Depression and World War II, Constructments sets occupy a specific place in the history of science; however, as I have argued, this story can deepen our understanding of the role and function of children's instruments in domestic education and of how learning about the sciences was often a social experience. The decorated box of a Constructments outfit drew attention to the company's aim of providing an educational and relatively affordable gift that would train boys and girls in scientific thinking: the company sold the very idea of becoming a scientist. Like similar systems created for experimental demonstration in the nineteenth century, Constructments sets were lauded as interchangeable mechanisms, capable of assuming different forms. The outfits familiarized users with the processes of building scientific instruments and licensed the creative development of new models and ideas. This emphasis on children constructing their own instruments was a celebration of the skills interwar consumers were expected to possess as they purchased and engaged with technologies. Thus, Hansel saw in Constructments the realization of teaching methods he first propounded in 1928, as the company's activities and products derived from the context of contemporary educational debates. For Hansel, the optical sciences provided a means of both connecting and introducing scientific disciplines, countering specialism with "general science" training in the skills of observation and deduction. Such an education equipped children with a set of mental skills applicable to a range of problems and fields: Constructments were part of an argument that scientific training provided the tools to succeed in a wide range of careers. In these ways, using Constructments enhanced mental processes of creativity and reasoning, as witnessed through the *Construmag*'s emphasis on children as "detectives." At the same time, a specifically scientific understanding of how instruments worked—such as the optical principles underlying the operation of a kaleidoscope—and the physical or mechanical skills of manipulating objects could also be imparted. Encouragement of the creation of Constructments clubs and the publication of the *Construmag* were means of defining this Constructments community of skilled individuals, creating a forum in which creative expertise could be imparted, shared, and standardized. As the toy sets' slogan affirmed, such a community would incorporate individuals of both sexes, rather than promoting the sciences as a male preserve. Moreover, and as contemporary users noted, far from the ease of assembly stressed in the promotional

[51] In Kelly's London Directory, Constructments Ltd. is listed from 1934 to 1937: J. Underwood, personal communication, 27 Oct. 2003; Guildhall Library's "list of dissolved companies, 1930–49," indicates that Constructments existed from 1932 to 1949. On the legislation prohibiting the manufacture of metal toys see Manduco, *Meccano Magazine* (cit. n. 42), p. 8; regarding BTH's wartime output see http://www.marconi.com/Home/about_us/Our%20History/GEC%20Heritage/British%20Thomson-Houston%20History (accessed 16 Dec. 2005).

[52] Robert Blyth, written response to a questionnaire, 2 Sept. 2004: "my early life was brought to an abrupt change by service in the Royal Artillery and the Royal Indians [*sic*] Artillery during the Second World War. But there again science entered the scene, as I became a Radar (or then, because of the high secrecy of the time, called Fire [gunfire] control) instructor. So, I was a technical instructor fire control, serving for a short time for the coast artillery school in Bombay. In the end, I was part of the forces being assembled on the East coast of India for the seaborne invasion of Malaya, which fortunately became unnecessary as a result of the atomic bombing of Japan. So I am still alive. Is or is not science wonderful? Incidentally, as well as Construmag, my periodicals as a teenager included Armchair Science & Discovery, which in its September 1939 edition forecast in a leading article, the atom bomb!"

material, building the optical instruments was often a tricky business, and a heterogeneous mix of people was crucial for Construments' success.

Thus, though Construments might at first glance appear to play a rather marginal role in the history of the scientific enterprise, these sets embodied many aspects of contemporary science and its education, as by putting together and playing with Construments components boys and girls trained themselves in the practices of scientific experiment and inquiry. We can agree with the *Times* journalist who, after visiting an educational exhibition in February 1934, concluded that Construments "are something a little *more* than a toy."[53]

[53] *London Times,* 20 Feb. 1934, p. 8 (emphasis added).